Medical Solution -DICOM Embedded Color LED Printer-

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OKI Data has commercialized color LED printers capable of receiving/interpreting and printing medical images transferred from medical equipment. The printers conform to the standardized medical image format and communication protocol DICOM (Digital Imaging and COmmunications in Medicine)[1] used for exchanging information between medical imaging equipment. This article presents the issues that were faced with DICOM printing support and the OKI printers that solved them.

Market Changes and Printing Needs Related to Medical Images

In the medical field, imaging equipment such as ultrasonic diagnostic equipment, CT (Computed Tomography), MRI (Magnetic Resonance Imaging) and X-Ray are collectively referred to as a modality. Medical images generated with a modality are exchanged using DICOM protocol/format.

Previously, medical image diagnosis (with X-Ray, CT, etc.) printed images on film, which were then interpreted by a radiologist. Now, transferring DICOM formatted digital images taken with diagnostic imaging equipment via network to a medical monitor for interpretation and diagnosis has become the mainstream method. Along with this trend, need for film printing is diminishing, but there are needs to make paper printouts for non-diagnosis purposes that include printing medical images in easy-to-understand explanatory material for patients due to the spread of informed consents and printing reference materials to be distributed at a medical institution's case briefings.

Issues with Conventional Medical Image Printing

DICOM formatted medical images generated by a modality is transferred using DICOM protocol. However, since typical office printers cannot interpret DICOM protocol or format, it is not possible for these printers to directly receive and print the images.

Thus, DICOM conversion software was installed in the server. The DICOM formatted images were converted via the server then printed using a print driver. The system configuration is shown in **Figure 1**.
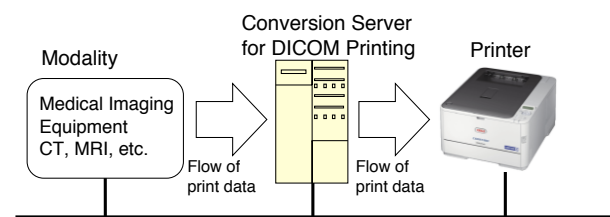

Figure 1. Conversion Server System for DICOM Printing

Nevertheless, the following issues exist.

(1) Requires conversion server

System building and maintenance are costly and troublesome.

2) Troublesome print quality adjustment

Images vary depending on the conversion software/print driver/printer combination and adjustments are troublesome.

(3) Complicated troubleshooting

When failure occurs, it is necessary to isolate the system component causing the problem.

(4) Increase in license fees

As the number of modality connections increase, additional license payments may become necessary.

OKI DICOM Embedded Color LED Printers

OKI DICOM embedded color LED printers conform to DICOM protocol/format and are capable of directly receiving and printing images from a modality. As a result, the above-mentioned issues were resolved in the following manner.

*1) DICOM is a trademark or registered trademark of the National Electrical Manufacturers Association.

(1) Simple installation

Installation is accomplished simply by registering a fixed IP address in the printer and connecting to the network. Once DICOM printing AET, IP address and port from the modality are specified, DICOM printing is useable. This eliminates the cost of server installation and the hassle of software installation and maintenance.

(2) Stable image quality

Since the printer integrally processes the job from communication to printing, a stable image quality is achieved.

(3) Simple troubleshooting

Since the printer singly handles DICOM communication and print processing, problem isolation during failure becomes simple and recovery is quicker.

(4) No license restrictions

Even if the number of modality increases, DICOM printer does not require payment of additional license fees.

Furthermore, with the use of a print driver, the DICOM printer can be used as a color LED printer to print office documents from PCs and workstations. A single DICOM printer can cover both medical image printing and general printing in a hospital thereby saving space.
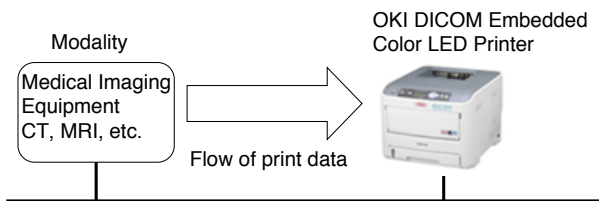

Figure 2. Medical Image Printing using OKI DICOM Embedded Color LED Printer

OKI DICOM Embedded Color LED Printers' System Configuration

The printer's system configuration is shown in **Figure 3**[1].

DICOM print server function is implemented in the printers as a Java application on top of the Java platform built into the printers. Left side of **Figure 3** is the printers' Controller Unit Firmware (CU F/W) and the right side is the Java execution environment. For more information on the built-in Java platform, see OKI Technical Review, April 2007/No. 210, "Ubiquitous Printing Services" (Reference 1).
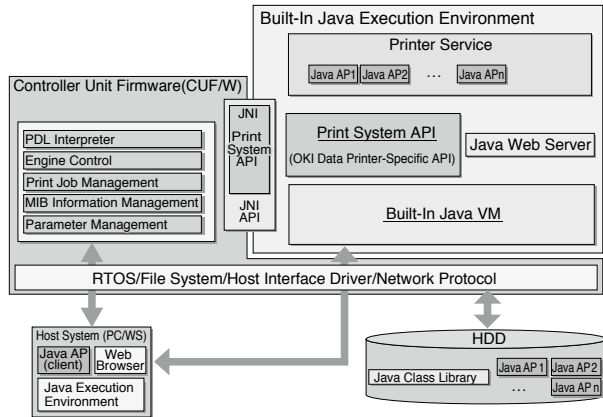

Figure 3. Implementation using Printer's Built-In Java*[2]

DICOM Standards and OKI's Printer Conformance

DICOM was jointly established by ACR (American College of Radiology) and NEMA (National Electrical Manufacturers Association), and they are continuing to work on its expansion.

Figure 4 is a list of DICOM standards[2].

DICOM Part 1: Introduction and Overview
DICOM Part 2: Conformance
DICOM Part 3: Information Object Definitions
DICOM Part 4: Service Class Specifications
DICOM Part 5: Data Structures and Encoding
DICOM Part 6: Data Dictionary
DICOM Part 7: Message Exchange
DICOM Part 8: Network Communication Support for Message Exchange
DICOM Part 10: Media Storage and File Format for Media Interchange
DICOM Part 11: Media Storage Application Profiles
DICOM Part 12: Media Formats and Physical Media for Media Interchange
DICOM Part 14: Grayscale Standard Display Function
DICOM Part 15: Security and System Management Profiles
DICOM Part 16: Content Mapping Resource
DICOM Part 17: Explanatory Information
DICOM Part 18: Web Services
DICOM Part 19: Application Hosting
DICOM Part 20: Imaging Reports using HL7 Clinical Document Architecture

Figure 4. DICOM Standards

DICOM embedded equipment such as modality does not fully support the enormous DICOM standard (2015 version: Part 1 – Part 20 totaling over 5,000 pages). The supported features of the standard are declared with a Conformance Statement that is made public to enable verification of interoperability between DICOM equipment. The contents structure of OKI printers' DICOM Conformance Statement is shown in **Figure 5** and a description example is shown in **Table 1**[3].

1. Introduction
2. Implementation model
3. Application Entity specifications
4. SOP Specific Conformance for Basic Grayscale Image Box SOP Class
5. SOP specific Conformance for Basic Color Image Box SOP Class
6. Specific Conformance for Presentation LUT Box SOP Class
7. Communication Profiles
8. Extensions/Specialization/Privatization
9. Configuration

**Figure 5. Conformance Statement Contents of
OKI DICOM Embedded Color LED Printers**

**Table 1. Description Example of DICOM
Conformance Statement**

Table A.1-1
NETWORK SERVICES

SOP Classes	User of Service (SCU)	Provider of Service (SCP)
Print Management		
Grayscale Print Management Meta	No	Yes
Color Print Management Meta	No	Yes
Presentation LUT	No	Yes
Print Job	No	Yes
Verification	No	Yes

Customizing DICOM Print Communication and Medical Image Print Settings

As previously described, OKI's DICOM embedded printers are designed to require only a simple installation for use. However, depending on use, modality type, medical institution's workflow, and other factors, customization related to image printing such as print media and image quality may be demanded. The printers are designed to meet those needs as well. The configuration of the base DICOM print communication will be explained first followed by a customization example.

(1) DICOM Print Communication

DICOM communication consists of SCU (Service Class User) that uses service and SCP (Service Class Provider) that provides service. In DICOM printing, the modality uses the print service and becomes the Print SCU (user side), whereas the printer provides service, thus it is the Print SCP (service side). This configuration is shown in **Figure 6**[4]. In the configuration of **Figure 1**, the conversion server for DICOM printing takes on the role of the Print SCP[4].
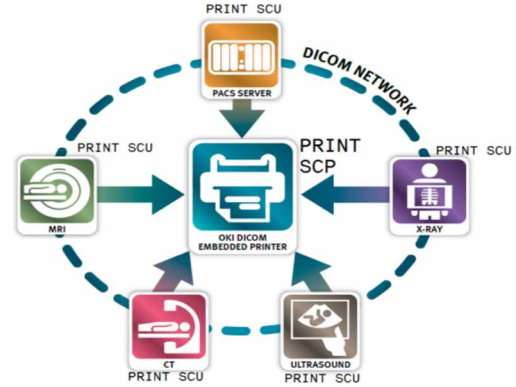

Figure 6. Print SCU and Print SCP

(2) AET Customization

From a dedicated web page, OKI DICOM embedded printer's settings such as those related to print media can be customized on an AET basis. AET (Application Entity Title) refers to the name used to identify application entities of DICOM embedded equipment. "OKI" is the default AET supplied with OKI DICOM color LED printers. Maximum of twenty-five AET can be defined in the printer allowing twenty-five different customizations. For example, the AET "OKIA4" and "OKIA3" can be defined for A4 printing and A3 printing, respectively. Then the modality can selectively choose between A4 printing and A3 printing by specifying the appropriate AET. **Figure 7** shows an example of the setup frame from the dedicated web page.

Figure 7. DICOM AET Parameter Setup Frame

DICOM Embedded Printer Lineup*[3)]

OKI Data's printers can be selected according to user needs, and the lineup includes the C610DM, C711DM A4 color LED printers and C831DM, C910DM A3 color LED printers. Photo of the products can be seen in **Figure 8** and product specifications are given in **Table 2**[5)].

C610 DM   C711 DM   C831 DM   C910 DM

Figure 8. Product Lineup

Table 2. OKI DICOM Embedded Color LED Printer Specifications

Model	C910DM	C831DM	C711DM	C610DM
Imaging Technology	Tandem CMYK color toner LED printer (600dpi LED array)			
Print Size	A3/Tabloid/A4/Letter		A4/Letter	
Network	Standardly equipped 10Base-T/ 100Base-X/ 1000Base-T	Standardly equipped 10Base-T/100Base-TX		
Maximum AET	25			
Maximum Number of Calling Modalities	No limitation			
Maximum Simultaneous Modality Connections	5	3	3	2
Printer Tray	Specify preferred paper tray			
Copy	Specify number of copies			
Border Density	Specify inter-image border color			
Empty Image Density	Specify empty image background color			
Header	Text header/Graphics header			
Footer	Text footer			
Contrast	Adjust contrast			
Brightness	Adjust brightness			
Gamma	Adjust gamma value			
Smoothing	Adjust Sharpen filter			
Polarity	Specify image polarity			
Log	Log DICOM communications			
Customization	Specify parameters from dedicated DICOM web page			

Using OKI's own LED as the light source, OKI DICOM embedded color LED printers have achieved high-speed, high gradation printing in a compact-sized equipment and gained high reputation at medical exhibitions. OKI will continually make improvements to match the needs of the medical field in an effort to provide more easy-to-use products. ◆◆

■References

1) Nakazato H., et. al: "Ubiquitous Printing Services," OKI Technical Review, April 2007/No. 210, Vol74. No.2, pp62-65
2) The DICOM Standard 2016a
   NEMA Homepage(http://dicom.nema.org/standard.html)
3) OKI Embedded server V.3.50.06 DICOM Conformance Statement Revision 1.0
4) OKI DICOM Printer Brochure (http://www.oki.com/eu/printing/images/DICOM_Brochure_tcm3-141822_tcm70-23040.pdf)
5) OKI DICOM MEDICAL PRINTERS Web Page (http://www.oki.com/eu/printing/products/colour/dicom/index.html)

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*3) The printers are not medical equipment and printed outputs cannot be used for making medical diagnosis.